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Division of Highways
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16. ABSTRACT
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The system functions adequately but requires much electronic support equipment in its use and instrumentation expertise for meaningful data acquisition.

17. KEYWORDS
Instrumentation, telemetry, data acquisition, vehicle-barrier crash test, accelerometer, seat belt force transducer, tape recorder.

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HIGHWAY RESEARCH REPORT

69-21

EVALUATION OF A TELEMETRY SYSTEM FOR USE IN VEHICLE-BARRIER IMPACT TESTS

INSTRUMENTATION REPORT

STATE OF CALIFORNIA BUSINESS & TRANSPORTATION AGENCY DEPARTMENT OF PUBLIC WORKS DIVISION OF HIGHWAYS	MATERIALS AND RESEARCH DEPARTMENT RESEARCH REPORT NO. M & R 636405-1

Prepared in Cooperation with the U.S. Department of Transportation, Bureau of Public Roads July, 1969

STATE OF CALIFORNIA—TRANSPORTATION AGENCY

RONALD REAGAN, Governor

DEPARTMENT OF PUBLIC WORKS
DIVISION OF HIGHWAYS
MATERIALS AND RESEARCH DEPARTMENT
5900 FOLSOM BLVD., SACRAMENTO 95819

July 1969

Instrumentation Report
M & R No. 636405-1
D-4-69

Mr. John Legarra
State Highway Engineer

Dear Sir:

Submitted herewith is a report titled:

EVALUATION OF A TELEMETRY SYSTEM

FOR USE IN

VEHICLE-BARRIER IMPACT TESTS

E. F. NORDLIN
Principal Investigator

W. H. Ames, L. G. Kubel, and W. Chow
Co-Principal Investigators

Very truly yours,

JOHN L. BEATON
Materials and Research Engineer

ABSTRACT

REFERENCE: Nordlin, E. F., Ames, W. H., Kubel, L. G., and Chow, W., "Evaluation of a Telemetry System for Use in Vehicle-Barrier Impact Tests", State of California, Department of Public Works, Division of Highways, Materials and Research Department. Research Report No. 636405-1 dated July 1969.

ABSTRACT: An instrumentation telemetry system for use in vehicle-barrier crash test data acquisition has been evaluated. This system, assembled by Wyle Laboratories of El Segundo, California, is called the Wyle Accident Simulation Measurement System. It consists of 7 channels of FM telemetry installable in a crash vehicle and 7 channels of hardwire telemetry installable on fixed barriers. The system includes 7 accelerometers and 2 seat belt force transducers and all necessary signal conditioning equipment for their use. The dynamic data from these transducers are recorded on a 14 channel analog magnetic tape recorder.

The system functions adequately but requires much electronic support equipment in its use and instrumentation expertise for meaningful data acquisition.

KEY WORDS: Instrumentation, telemetry, data acquisition, vehicle-barrier crash test, accelerometer, seat belt force transducer, tape recorder.

[illegible] of 7 channels [illegible]

[illegible] conditioning equipment [illegible]

[illegible] those areas are [illegible]

[illegible] especially but requires much [illegible]

[illegible] its use and interpretation [illegible]

[illegible] accurate evaluation [illegible]

[illegible] reviewers, data acquisition [illegible]

ACKNOWLEDGEMENTS

The researchers wish to express their appreciation to the Bureau of Public Roads for the loan of the Wyle Accident Simulation Measurement System for use in the California Division of Highways barrier research program.

This is the first in a series of reports to be issued for a research project titled "Energy Absorbing Highway Barrier Designs". This work is being accomplished under Item D-4-69 in the 1968-69 Work Program HPR-PR-1(6), in cooperation with the U. S. Department of Transportation, Federal Highway Administration, Bureau of Public Roads.

The opinions, findings, and conclusions expressed in this publication are those of the authors and not necessarily those of the Bureau of Public Roads.

I. INTRODUCTION

The California Division of Highways is in a continuing program to upgrade the safety aspects of their highway-vehicle barriers. This involves the full-scale testing of various barrier designs by impacting vehicles into them. Of paramount importance is acquisition of the physical data (acceleration, deceleration, force, time, velocity, etc.) during these tests, both from within the vehicle and from the barrier. The impact data from within the vehicle may be acquired by:

1. Recording the vehicle and dummy occupant impact data directly onto a recorder mounted inside of the crash vehicle.

2. Recording the vehicle and dummy occupant impact data through a tether cable connected to a recorder mounted in a follow-up vehicle.

3. Transmitting the vehicle and dummy occupant impact data through a radio transmitter mounted in the impact vehicle to a ground receiving station.

This report concerns the last of the three described methods and reports the California Division of Highways' experience, trials, modifications, and assessment of a radio telemetry type system assembled by Wyle Laboratories of 128 Maryland Street, El Segundo, California. This system is called the Wyle Accident Simulation Measurement System.

Basically, this system was assembled and packaged by Wyle for the Bureau of Public Roads from commercially available instruments on the market. The instruments and accessories comprising the system and its accessories are shown in Figures 5, 6, 7, 8, and a system block diagram is shown in Figure 12.

The Wyle Accident Simulation Measurement System is on loan from the U. S. Department of Transportation, Bureau of Public Roads to the Division of Highways for their use and evaluation. The use and evaluation of the Wyle system was performed under the Division of Highways Research Project No. M & R 636405, "Energy Absorbing Highway Barrier Designs", D-4-69.

II. CONCLUSIONS-ASSESSMENT OF THE COMPLETE SYSTEM

To date (June 1969) assessment of the Wyle Accident Simulation Measurement System is based upon the California Division of Highways' experience with it during three vehicle impact tests and numerous checkout and debugging trials.

It is the opinion of the researchers that meaningful data can be obtained from this system provided that it is operated by engineers with expertise in the instrumentation, telemetry, and magnetic tape recording fields. This system is very complex and this expertise is made even more mandatory because of the lack of detailed instructions, technical information, and engineering data (particularly with the Industrial Electronetics radio telemetry unit) supplied with the system. For the unwary, the system is fraught with pitfalls so that its rote use could produce questionable data.

In addition, the expertise required must also be "backed-up" by a well equipped electronic instrumentation laboratory. The system as supplied contained no test or calibration instruments and, most important, no visual playback instrument. In Figure 5 and Figure 5a, Items 5 through 16, note the minimum amount of electronic instruments supplied by the California Division of Highways' laboratory in order to set up the system, record the "accident", and playback the "accident" for visual analysis.

III. TELEMETRY SYSTEM

The telemetry components of the Wyle system package were manufactured by Industrial Electronetics who do not state their system's radio range (distance) reception. However, they do state, "The use of this FM band is permitted by the Federal Communication Commission under the restricted radiation clause wherein transmission is limited to the confines of the owner's property and the transmission does not interfere with commercially licensed stations." Therefore, the Division of Highways' experience with the Industrial Electronetics Telemetry System indicates that it meets the above FCC requirement, but its use in the Division of Highways' range requirement (700 feet) is beyond its capability.

The Industrial Electronetics Telemetry System is indeed a low range radio system. Ron Scott of Wyle advised W. Chow on August 1, 1968, that John Webster of Industrial Electronetics had given him (Scott) the following information as the IE telemetry system:

1. Transmitter has an output of about 2 milliwatts but that this value was very difficult to ascertain positively. (We measured 0.6 milliwatts output).

2. Receiver sensitivity is 1-2 microvolts. (we measured 8 to 16 microvolts sensitivity for 20 db quieting).

3. System is very susceptible to ignition noise. Our (Division of Highways) ignition noise problems are normal and the transmitter-receiver must be separated by less than 100 feet for adequate reduction of ignition noise. IE stated that they have similar ignition noise problems.

The major inadequacy of this system, for the Division of Highways' purpose, has been the low range reception between the transmitter and the receiver (see Figure 11). In a crash test the crash car and the transmitter in it may be 700 feet down range from the receiving antenna. This means that during a large portion of the car run-in the transmitter is beyond the range of the receiver, while the car is coming towards the crash point, until the 300 feet point is reached (see Figure 11) wherein the transmitter is in the range of the receiver.

The above inadequacy created another problem in that the AFC (automatic frequency control) in the receiver had to be turned off when the receiver is in a metropolitan area to avoid seeking stray signals. At a down range distance of 700 feet the receiver was too far from the transmitter to receive and lock on to it; therefore, if the AFC was on, it would seek to lock-on to any available FM signal in the air or possibly to lock-on to the wrong channel of the transmitter as it came into the receiver range. With the AFC off, this affected the receiver operation by causing it to drift off "station". After the first test, it was decided that the station drift could not be tolerated, and the AFC was utilized for subsequent tests. This decision was justified since our crash test site (Lincoln, California) is located in a remote area which is relatively free from FM stations.

Initially no signal was received on channel 2. The problem was located and was due to a female clip missing on its BNC connector in the transmitter.

The tuning slugs for the transmitter (carrier) appeared to be loose and may have contributed to the carrier drift. Therefore, fingernail polish was applied to each of the slugs to affix them permanently in position after realignment. However, several of the receiver tuning slugs were frozen tight so that no adjustments could be made. Furthermore, since Industrial Electronetics supplied no alignment procedure or voltage adjustment range, no further attempt was made to align the telemetry system.

The 20 mv quiescent output (noise) of the telemetry channels is excessive. For example, if 500 mv is the full scale output of a particular accelerometer telemetry channel and the accelerometer sustains a 100 mv "crash", then the 20 mv of noise superimposed on it would represent a +20% error in the 100 mv "crash".

Although the Industrial Electronetics instructions indicate satisfactory operation with the transmitter batteries down to 7.7 volts, the Division of Highways' experience indicates excessive SCO (sub-carrier oscillator) drift when battery voltage is below 8.75 volts. Therefore, voltage must be maintained above 8.75 volts for drift-free operations.

The seven indicating meter's center position did not always indicate the best receiver tuning. This is probably due to the improper or inaccurate FM discriminator alignment. It was found necessary to tune each of the 7 receivers for their best sinusoidal waveform (not amplitude) while monitoring it on an oscilloscope. The oscilloscope also afforded a visual indication of correct tuning, which is essential, because incorrect tuning produced high frequency noise and distortion of the sine wave.

The system comes supplied with five (20" long) transmitting antennae (Figures 6-2 and 13). One of the antennae was inoperative when received because it had a fractured soldered connection between the cup base and the antenna. All of the antennae should be examined occasionally for such possible defects. Care should be taken to remove the paint from beneath the antenna mount on the crash vehicle to assure a good ground connection.

The transmitting antenna should be mounted directly in the center of the crash vehicle's roof. This is so that the antenna may have a symmetrical ground-plane in which to reflect its radio signal. Antenna off-center mounting could contribute to telemetry signal drop-off.

The antennae supplied with the system were 20" long, apparently cut for 1/4 wave length at 140 megahertz. Since the system is in the FM band (88 to 108 megahertz), a 31" length antenna was used in lieu of one of the 20" antennae. This longer antenna was cut for 1/4 wave length at 95 megahertz, or in roughly the middle of the FM band, and has given better reception than the 20" antenna.

The system is supplied with a 5 element Yagi receiving antenna (Figure 8). Its coverage is approximately 160° in a 300 foot radius as shown in Figure 11. Contrary to the usual home TV antenna orientation, the best reception is obtained with the antenna plane oriented perpendicular to the ground as shown in Figure 8. This orientation produces a common polarization plane between the transmitting and receiving antennae and therefore the optimum reception.

IV. ACCELEROMETERS

The Statham series A514Tc accelerometers (Figure 6-5) supplied with this system cannot be subjected to rough handling like the Division of Highways' Statham series A5a accelerometers (Figure 6-4). One of the A514Tc Stathams became inoperative simply by lightly tapping it with a screwdriver handle and another apparently due to rough handling. Repair of these accelerometers is time-consuming and costly. The Statham Company required 5 months and $250 for each repair. It is suggested that the Statham A5a series be used in lieu of the Statham A514Tc because of its inherent ruggedness.

Wyle supplied a 350 ohm calibration test bridge substitution box (Figure 6-7) for calibration of the accelerometer telemetry channels (Figure 6-1). However, use of this box was an awkward procedure in the field necessitating the complete removal of each accelerometer connection plug from its telemetry channel and the reconnection of the substitution box's connection plug into each telemetry channel, a channel at a time. Wyle's reason for this substitution box was that a shunt calibrate resistor across an accelerometer created capacitance problems in the telemetry channels. However, the Division of Highways has used calibrate resistors from a decade resistor box (Figure 6-9) across each accelerometer, in lieu of the substitution box, and experienced no difficulties. The shunt calibrate resistor values for direct connection across each accelerometer supplied in the system are listed in Figure 9, "Barrier System". The shunt resistor values listed in Figure 10, "Telemetry System", are to be used only with the substitution box. Note that the shunt resistor values for a given acceleration are different for the two "systems".

The excitation voltage to the accelerometers is 1.3 volts at a nominal 4K Hz when connected to the Industrial Electronetics telemetry system.

V. SEAT-BELT TRANSDUCERS

The BLH seat-belt transducers (Figure 6-6) presented no particular problem except that its designed resistance of 120 ohms could more conveniently have been 350 ohms for uniformity with the Statham 350 ohms accelerometers.

The comments about the dummy bridge substitution box in Part IV - "Accelerometers" also applies here. The Division of Highways eliminated the use of the 120 ohm dummy bridge substitution box (Figure 6-8) and successfully used calibrate resistors directly across the seat-belt transducers in a similar fashion previously described for accelerometers.

The excitation voltage to the seat-belt transducer is also 1.3 volts at a nominal 4K Hz.

VI. DATA PLAYBACK AND ANALYSIS

Although the Wyle system does not include visual playback instrumentation, the Division of Highways data playback method and analysis is included herein to demonstrate more fully the "total method" involved in acquiring meaningful data and analysis.

The two playback records included herein as illustrations (Figures 14 and 15) are from the Division of Highways' vehicle crash test #214 conducted on September 25, 1968. It shows the car deceleration due to impact, without filtering, in Figure 14 and with filtering in Figure 15.

High frequency "ringing" of the car chassis during impact (Figure 14) created difficulty in data analysis. Therefore, the magnetic tape recordings were played back with a Krohn-Hite filter set to attenuate frequencies above 12 Hertz. Since the actual impact test was originally recorded at a tape speed of 30 ips and played back at 3-3/4 ips (speed reduction of 8 to 1), the real-time filtering of the impact signal is 96 Hertz (8 x 12 = 96). In other words, the filter is set to attenuate real-time signal frequencies above 96 Hertz. As previously mentioned, Figure 15 is the filtered record of Figure 14 and indicates that the car sustained a maximum deceleration of 12.4 G's.

Further analysis of the car deceleration was performed by the use of an EAI-Pace model TR-10 analog computer. A diagram of the analog computer setup is shown in Figure 17. Vehicle crash test #214, channel 2 again is used for illustration.

The vehicle crash test deceleration signal was fed into the analog computer and integrated twice. The first integration of acceleration produced the vehicle's velocity and the second integration produced the car's penetration (distance) into the barrier. A plot of the double integration (velocity and distance) resulting from the analog computer operation is shown in Figure 18.

Examination of Figure 18 shows that the impact duration was 0.4 seconds because the car velocity reached zero at that time and the car had penetrated into the barrier 10.1 foot in coming to rest in that time period. The analog computation of the original car deceleration signal has produced two additional meaningful car crash parameters: distance of car travel and car velocity during impact.

Figure 1

WYLE SYSTEMS

A Division of Wyle Laboratories
128 Maryland Street
El Segundo, California 90245
678-4251 Area Code 213
TWX 910-348-6283 Cable WYLAB

SHIPPING MEMORANDUM

№ 9011

Calif. Div. of Highways
Material and Research Dept.
5900 Folsom Blvd.
Sacramento, Calif.
Attn: Eric Nordlin

DATE July 17, 1968
JOB NO. 14544-11
P. O. NO.
AUTHORIZED BY J. Wood
ATTENTION OF Eric Nordlin

ROUTING: FC ☐ SD ☐ PP ☐ UPS ☐ RAIL ☐ AIR ☒ EXP. ☐ FRT. ☐ OT ☐ OTHER

INSURANCE: $50.00 ☐ $100.00 ☐ $200.00 ☐ $500.00 ☐ OTHER MARKING FRAGILE: ☐ THIS SIDE UP ☐

OTHER SHIPPING INSTRUCTIONS

ITEM	QUANTITY	DESCRIPTION
1	1	Tape recorder, CEC VR-3300, S/N F4224-(133300) with a 14 channel of record and reproduce electronics for 60, 30, 7 1/2, 3 3/4, 1 7/8 IPS voice channel with microphone, and reel revolution counter.
2	7	Signal conditioning module, Endevco 4401 S/N SA34, SA35, SA36, SA37, SA38, SA39, SA40.
3	5	Potentiometer mode cards, Endevco 4400-20
4	5	Resistance Bulb mode cards, Endevco 4400-30
5	5	Strain Gage mode cards, Endevco 4400-10
6	1	Rack Adapter, Endevco 4975B

1M SETS 5-68 T-7203

CUSTOMER

Figure 2

WYLE SYSTEMS

A Division of Wyle Laboratories
128 Maryland Street
El Segundo, California 90245
678-4251 Area Code 213
TWX 910-348-6283 Cable WYLAB

SHIPPING MEMORANDUM

№ 9015DD
9011
Page 2 of 4

Calif. Div. of Highways
Material and Research Dept.
5900 Folsom Blvd.
Sacramento, Calif.
Attn: Eric Nordlin

DATE
JOB NO.
P. O. NO.
AUTHORIZED BY
ATTENTION OF

ROUTING: FC ☐ SD ☐ PP ☐ UPS ☐ RAIL ☐ AIR ☐ EXP. ☐ FRT. ☐ OT ☐ OTHER
INSURANCE: $50.00 ☐ $100.00 ☐ $200.00 ☐ $500.00 ☐ OTHER MARKING FRAGILE: ☐ THIS SIDE UP ☐
OTHER SHIPPING INSTRUCTIONS

ITEM	QUANTITY	DESCRIPTION
7	7	Differential Amplifiers, Dynamics Instrumentation 7514B/J, S/N 1431, 1432, 1433, 1434, 1435, 1436, 1437.
8	1	Rack Adaptor, Dynamics Instrumentation 7914R
9	1	VHF Amplifier, Jerrold 3660, S/N 4485
10	1	VHF Antenna, Jerrold FAX 5
11	7	In-Line Tap, Jerrold 1401Y
12	1	Termination Tesistor, Jerrold TR-72
13	4 ~~5~~	Accelerometer, Statham A514TC-50-350 S/N 2062 2077, 2080, 2081
14	3	Accelerometer, Statham A514TC-100-350, S/N 2084, 2083, 2085
15	2	Tension Transducer, BLHP-265, S/N W-437 W-438

1M SETS 5-68 T-7203

CUSTOMER

Figure 3

WYLE SYSTEMS

A Division of Wyle Laboratories
128 Maryland Street
El Segundo, California 90245
678-4251 Area Code 213
TWX 910-348-6283 Cable WYLAB

SHIPPING MEMORANDUM

№ XXXXXX 9011
Page 3 of 4

Calif. Div. of Highways
Materials and Research Dept.
5900 Folsom Blvd.
Sacramento, Calif.
Attn: Eric Nordlin

DATE ____
JOB NO. ____
P. O. NO. ____
AUTHORIZED BY ____
ATTENTION OF ____

ROUTING: FC ☐ SD ☐ PP ☐ UPS ☐ RAIL ☐ AIR ☐ EXP. ☐ FRT. ☐ OT ☐ OTHER ____
INSURANCE: $50.00 ☐ $100.00 ☐ $200.00 ☐ $500.00 ☐ OTHER ____ MARKING FRAGILE: ☐ THIS SIDE UP ☐
OTHER SHIPPING INSTRUCTIONS ____

Have 7

ITEM	QUANTITY	DESCRIPTION
16	6 4	Telemetry Receiver, Industrial Electronetics R-71, S/N 291B, 335B, 351B, 353B, 370B, 429B
17	7	Telemetry Transmitters, Industrial Electronetics, T-62A, S/N B-75, B-77, B-078, B-79, B-81, B-84 B-87
18	4	Batteries, Industrial Electronetics E7
19	1	Battery Charger, Industrial Electronetics BC-45-4
20	2	Whip Antenna, Modified New-'Tronics UHT-1
21	1	Instruction Manual, CEC VR-3300
22	1	Instruction Manual, Endevco 4401
23	1	Instruction Manual, Dynamics 7514B/J
24	1	Instruction Manual, Industrial Electronetics Telemetry System.
25	lot	Preliminary System Drawings
26	2	125 foot extension cables
27	lot	misc. cables

1M SETS 5-68 T-7203

CUSTOMER

WYLE SYSTEMS
A Division of Wyle Laboratories
128 Maryland Street
El Segundo, California 90245
678-4251 Area Code 213
TWX 910-348-6283 Cable WYLAB

SHIPPING MEMORANDUM

Nº ~~9013~~ 9011

Calif. Div. of Highways
Material and Research Dept.
5900 Folsom Blvd.
Sacramento, Calif.
Attn: Eric Nordlin

DATE ____
JOB NO. ____
P. O. NO. ____
AUTHORIZED BY ____
ATTENTION OF ____

ROUTING: FC ☐ SD ☐ PP ☐ UPS ☐ RAIL ☐ AIR ☐ EXP. ☐ FRT. ☐ OT ☐ OTHER ____
INSURANCE: $50.00 ☐ $100.00 ☐ $200.00 ☐ $500.00 ☐ OTHER ____ MARKING FRAGILE: ☐ THIS SIDE UP ☐
OTHER SHIPPING INSTRUCTIONS ____

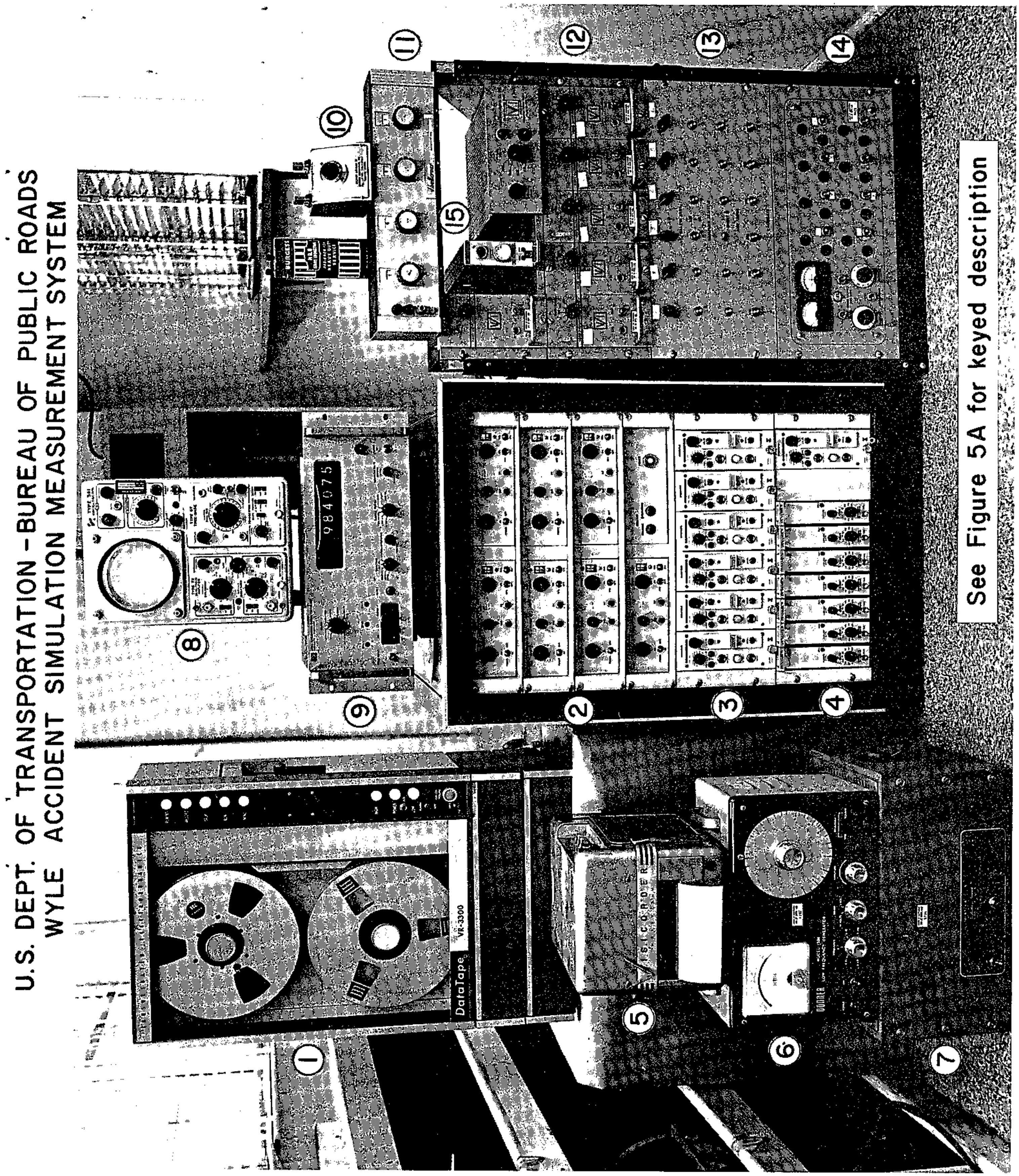
ITEM	QUANTITY	DESCRIPTION		
28	1	Seven channel junction box with mating connectors		
29	1	350 ohm test bridge		
30	1	120 ohm test bridge		
31	lot	Seat belt material, United Tent and Supply WN-1327		
32	1	Cabinet, Electronic Enclosures EES-1-28-30		
33	1	Telemetry Transmitter Enclosure, seven channel Wyle Systems		
34	1	Power Panel, Wyle Systems 6003		

1M SETS 5-68 T-7203

CUSTOMER

Figure 4

Figure 5


U.S. DEPT. OF TRANSPORTATION - BUREAU OF PUBLIC ROADS
WYLE ACCIDENT SIMULATION MEASUREMENT SYSTEM
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
DataTape
VR-3300
984075
See Figure 5A for keyed description

Components of the Wyle Accident Simulation Measurement System:

1. Consolidated Electrodynamics Corporation Model VR-3300 magnetic record-reproduce tape transport.

2. 7 channels of Industrial Electronetics Corp. Model R-71 telemetry receivers.

3. 7 channels of Endevco Corp. Model 4401 signal conditioning modules.

4. 7 channels of Dynamic Instrumentation Company Model 7514 B/J differential amplifiers.

California Division of Highways Equipment:

5. Honeywell Visicorder Oscillograph Model 906.

6. Systron-Donner function generator Model 1500.

7. Sorensen AC voltage regulator Model 1001.

8. Tektronix oscilloscope Model 561.

9. Hewlett-Packard digital voltmeter Model 2401C.

10. Helipot potentiometer Model T-10A.

11. Shallcross decade resistor box Model 6866.

12. Video DC amplifiers Model 72R.

13. Galvanometer control panel.

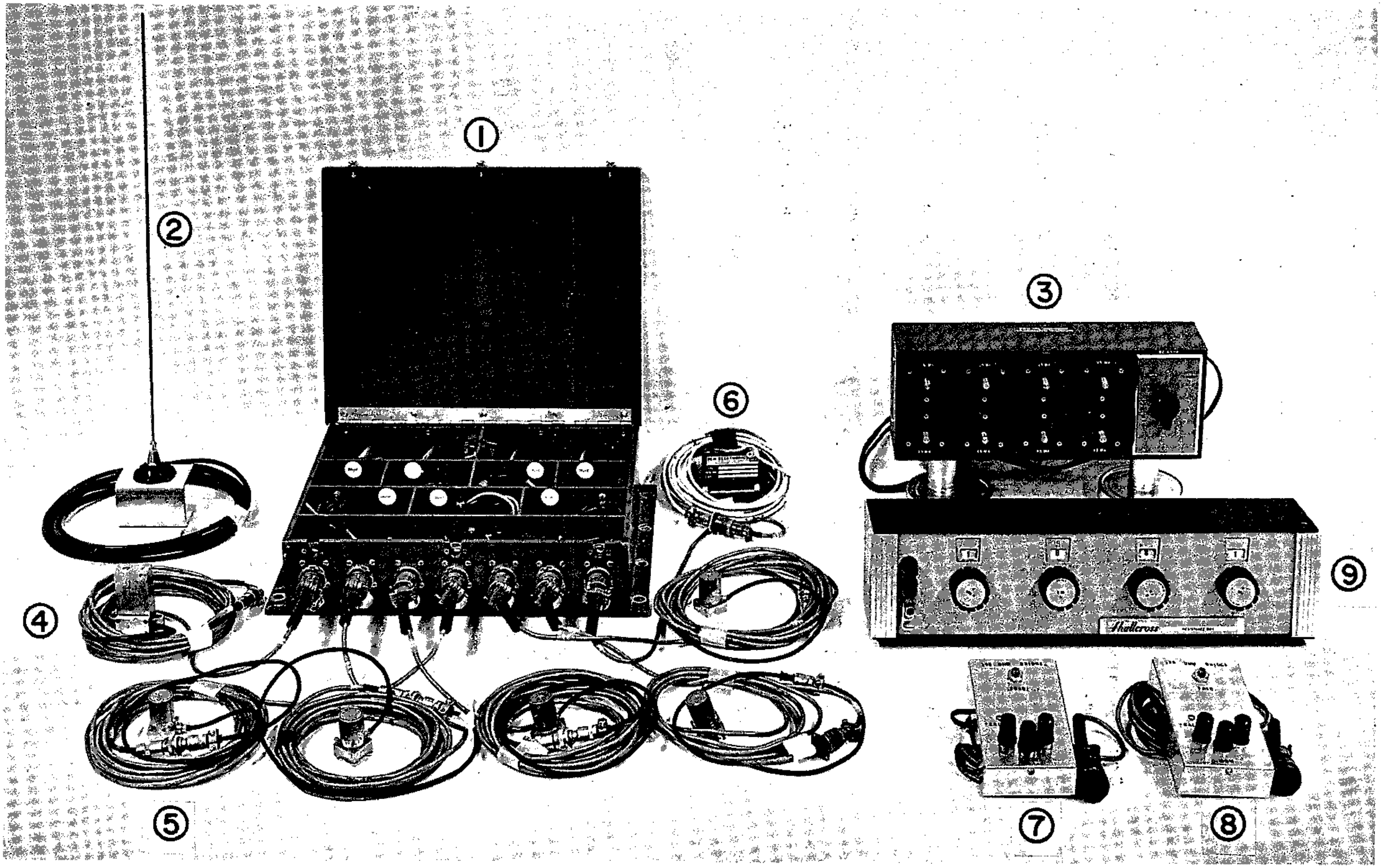
14. Consolidated Electrodynamics bridge balance Model 18-108.

15. Video Model SR-1000 D.C. power supply.

16. Krohn-Hite Electronic Filter Model 335 (not shown).

Figure 6

U.S. DEPT. OF TRANSPORTATION - BUREAU OF PUBLIC ROADS
WYLE ACCIDENT SIMULATION MEASUREMENT SYSTEM



See Figure 6A for keyed description

Components of the Wyle Accident Simulation Measurement System:

1. 7 channels of Industrial Electronetics Corp. Model T62-A transmitters.

2. Transmitting antenna.

3. Industrial Electronetics battery charger Model BC-45-4.

5. 5 Statham Model A514Tc accelerometers (2 not shown).

6. BLH seat belt transducer Model BLHP0265.

7. 350 ohm calibration test bridge.

8. 120 ohm calibration test bridge.

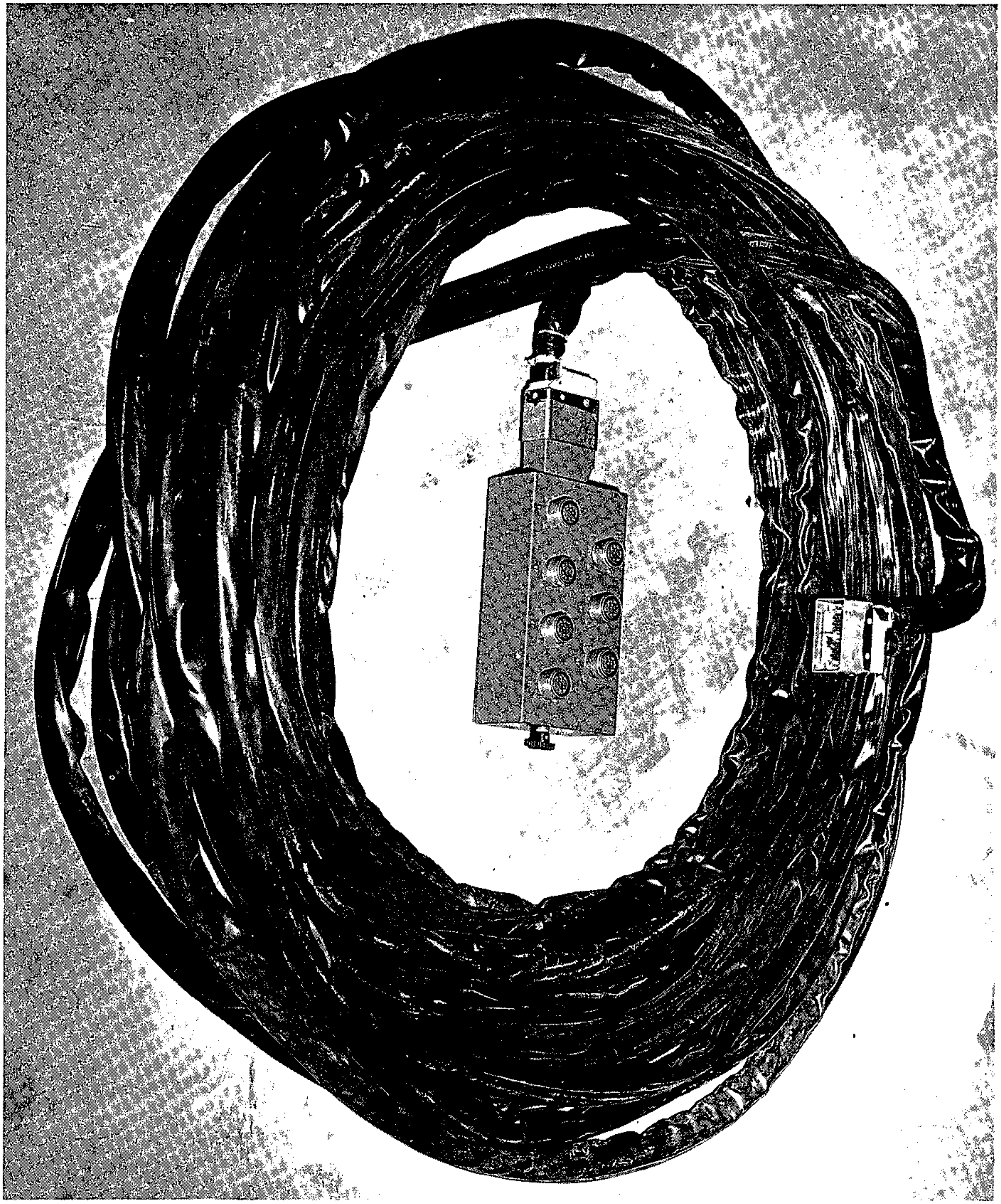
California Division of Highways Equipment:

4. Statham accelerometer Model A5a.

9. Shallcross decade resistor box Model 6844.

Figure 7

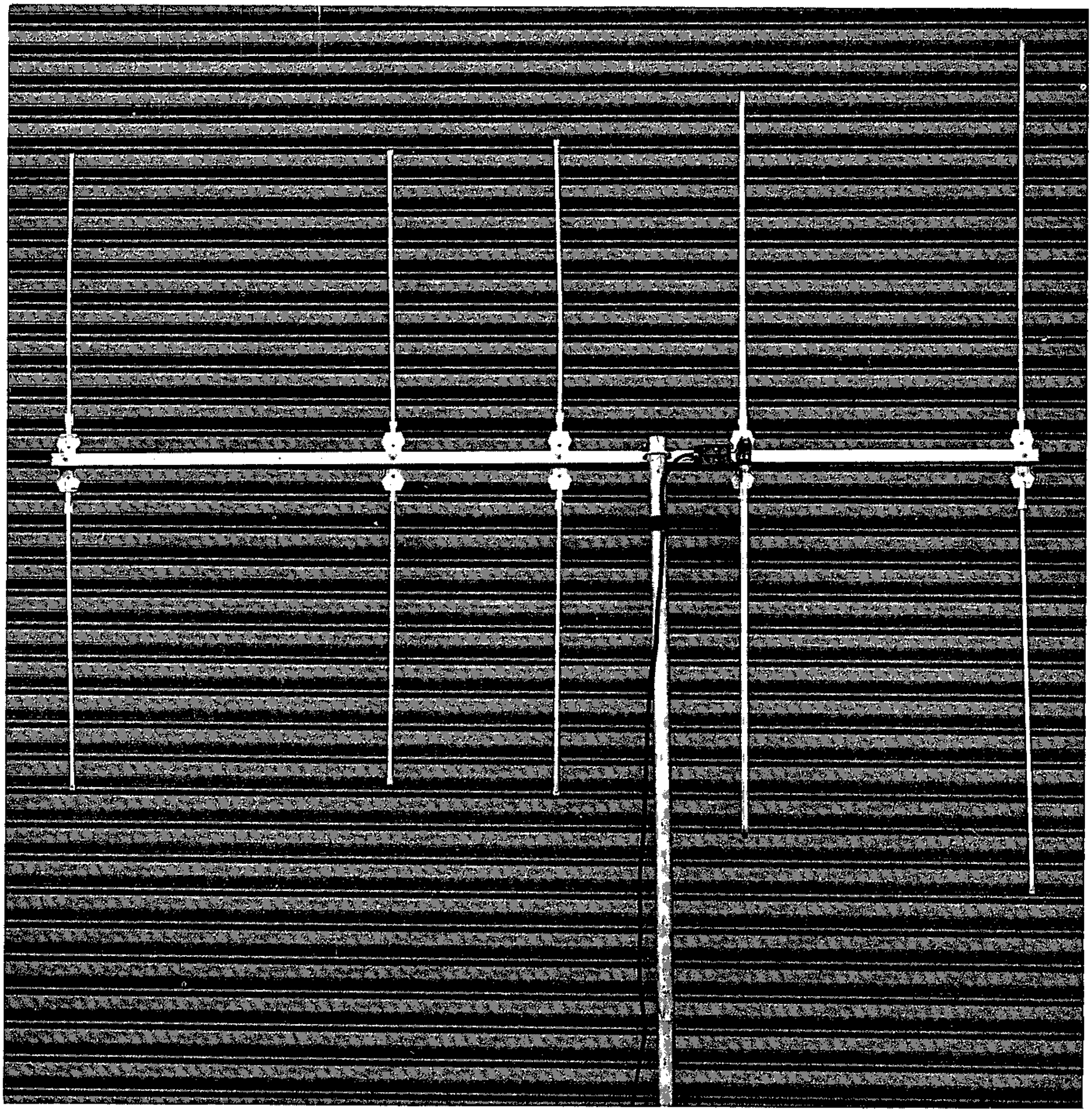
U.S. DEPT. OF TRANSPORTATION - BUREAU OF PUBLIC ROADS
WYLE ACCIDENT SIMULATION MEASUREMENT SYSTEM



Ground channel data cable and junction box with mating connectors.

Figure 8

U.S. DEPT. OF TRANSPORTATION - BUREAU OF PUBLIC ROADS
WYLE ACCIDENT SIMULATION MEASUREMENT SYSTEM



Yagi 5 element receiving antenna

FIGURE 9

U. S. DEPARTMENT OF TRANSPORTATION - BUREAU OF PUBLIC ROADS

WYLE ACCIDENT SIMULATION MEASUREMENT SYSTEM

BARRIER SYSTEM

TRANSDUCER SHUNT RESISTANCE CALIBRATIONS

Accelerometer	Serial No.	Range	Shunt Resistance 10g	20g	30g	40g	50g	100g
Statham A 514 Tc	2081	± 50g	80k	40k	26.6k	20k	16k	
Statham A 514 Tc	2083	±100g	170k	85k	56.6k	42.5k	34k	17k
Statham A 514 Tc	2084	±100g	222k	111k	74k	55.5k	44.4k	22.2k
Statham A 514 Tc	2085*	±100g	180k	90k	60k	45k	36k	18k
Statham A 514 Tc	2062	± 50g	103k	51.5k	34.3k	25.7k	20.6k	
Statham A 514 Tc	2077	± 50g	94.5k	47.3k	31.5k	23.6k	18.9k	
Statham A 514 Tc	2080**	± 50g	89k	44.5k	29.6k	22.2k	17.8k	

Seat-Belt Transducer	Serial No.	Range	500#	1000#	1500#	2000#	2500#	3000#	3500#
BLH	W-438	4500#	134k	67k	44.6k	33.5k	26.8k	22.3k	19.1k
BLH	W-437	4500#	138k	69k	46k	34.5k	27.6k	23k	19.7k

* Repaired 5-29-69

** Repaired 3-26-69

FIGURE 10

U. S. DEPARTMENT OF TRANSPORTATION - BUREAU OF PUBLIC ROADS

WYLE ACCIDENT SIMULATION MEASUREMENT SYSTEM

TELEMETRY SYSTEM

TRANSDUCER SHUNT RESISTANCE CALIBRATIONS

Accelerometer	Serial No.	Range	Shunt Resistance 10g	20g	30g	40g	50g	100g
Statham A 514 Tc	2081	± 50g	82k	41.2k	27k	20k	16.2k	
Statham A 514 Tc	2083	±100g	186k	92k	60.9k	44.6k	36.2k	18.1k
Statham A 514 Tc	2084	±100g	215k	105k	70k	51.6k	41.6k	20.8k
Statham A 514 Tc	2085	±100g	Repaired 5-29-69 No value.					
Statham A 514 Tc	2062	± 50g	103k	50.5k	33.7k	25.1k	19.9k	
Statham A 514 Tc	2077	± 50g	100k	49.1k	33.1k	24.8k	19.9k	
Statham A 514 Tc	2080	± 50g	Repaired 3-26-69 No value.					

Seat-Belt Transducer	Serial No.	Range	500#	1000#	1500#	2000#	3000#	3500#
BLH	W-438	4500#	117k	58.6k	39.6k	29.9k	20.1k	17.2k
BLH	W-437	4500#	141k	67.9k	44.6k	33k	22.2k	19.1k

Figure 11

WYLE TELEMETRY SYSTEM
RECEIVING ANTENNA COVERAGE

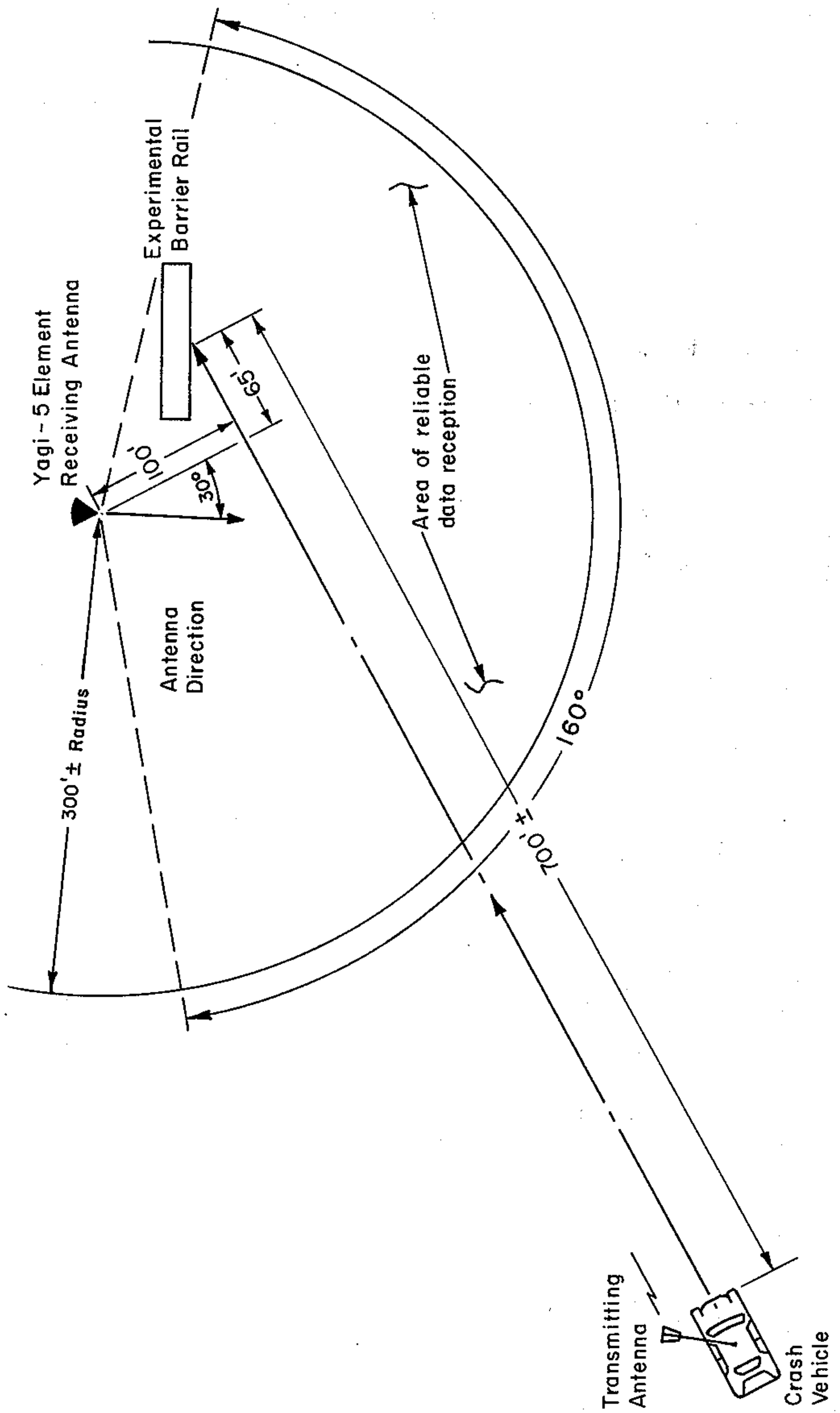
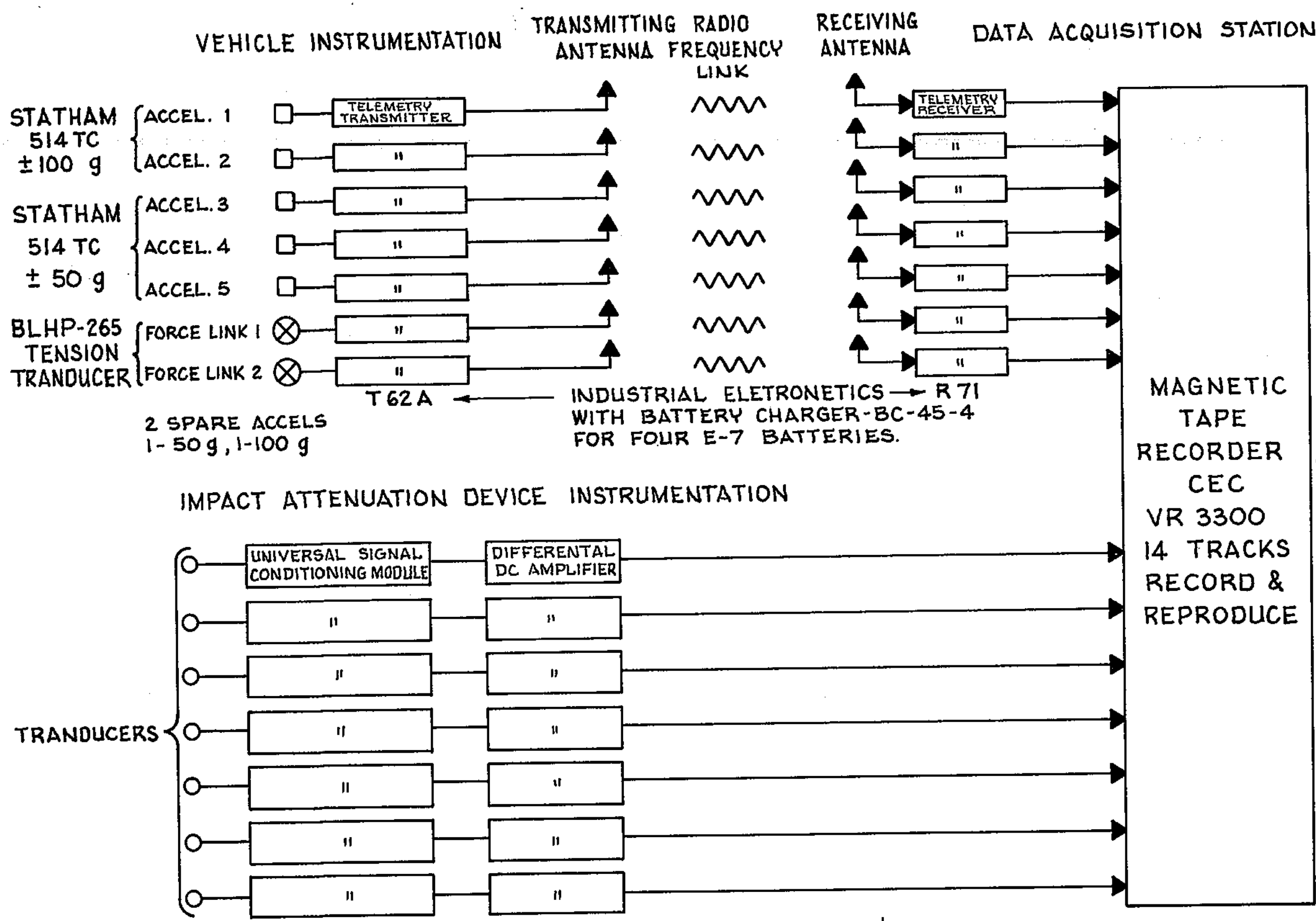
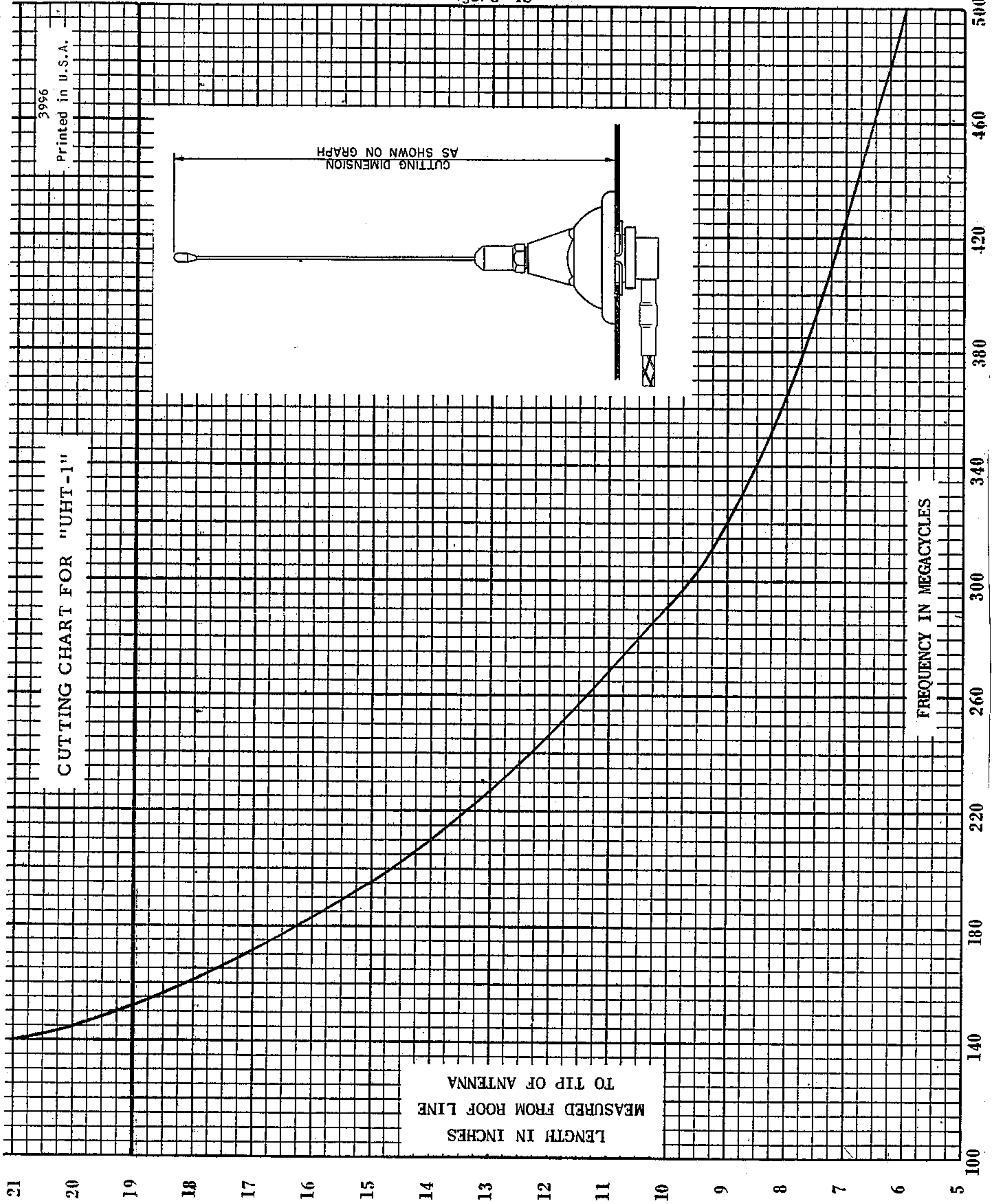


Figure 12



BLOCK DIAGRAM OF DATA ACQUISITION SYSTEM
WYLE ACCIDENT SIMULATION MEASUREMENT SYSTEM

Figure 13


CUTTING CHART FOR "UHT-1"
3996
Printed in U.S.A.
CUTTING DIMENSION
AS SHOWN ON GRAPH
FREQUENCY IN MEGACYCLES
LENGTH IN INCHES
MEASURED FROM ROOF LINE
TO TIP OF ANTENNA
100
140
180
220
260
300
340
380
420
460
500
21
20
19
18
17
16
15
14
13
12
11
10
9
8
7
6
5